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Soil moisture variation under bare conditions at Pune and Delhi in relation to rainfall

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ABSTRACT. Soil moisture variation in bare soil of various depths at Pune and Delhi has been examined week by week. The study has brought out that soil moisture reaches field capacity at Pune on a few occasions and almost every year at Delhi area specially in late monsoon. There may not be any carry over of moisture for the next season at Pune but forced fallows may benefit the succeeding crop at Delhi.

1. Introduction

Fluctuation of soil moisture should properly be evaluated for comprehensive understanding of the inter relationship between the moisture at root zone and plant growth. In regions of erratic rainfall and pronounced mid-season breaks, sowing of crops towards the close or after cessation of the rainy season, is often resorted to. Early harvest of the crops at appropriate physiological maturity is advocated for conservation of root zone moisture to the succeeding crop. Similarly, a forced fallow year is supposed to be beneficial to the crop in the succeeding year.

Ramdas and associates (1934-52) have investigated many aspects of the movement of moisture through soil and its evaporation from the soil surface. Studies in the physics of evaporation from bare soil indicate that the extent and depth to reduction of moisture contents of soils due to moisture transport in the vapour phase vary widely. A depletion is greatly magnified in soils which develop cracks on drying.

In the light of the above, moisture variations at the rooting depths of crops, in cracking and non-cracking soils under bare conditions, during the rainy season and in the dry season, are of importance from the point of view of crop practices and conservation of moisture. The same quantity of rainfall affects the soil moisture differently under different soil depths and location of the site. The prime requirement of the agriculturists in the area of scanty rainfall is a system of efficient utilisation of soil moisture to augment agricultural production. For this, fluctuation of soil moisture in different months of the year due to variable rainfall should be known. Therefore, a study of the intra-annual fluctuations of moisture at Pune and Delhi in bare soil at different depths was undertaken.

2. Data

Soil moisture observations have been routinely recorded, in bare condition once in a week at four depths, *i.e.*, 7·5, 15, 30, 45 cm at Pune and fortnightly at 15, 30, 45 and 60 cm at Delhi. In these, soil moisture is expressed as percentage by weight of dry soil. The data from June 1960 to May 1974 of Pune and from June 1957 to May 1972 of Delhi along with weekly/fortnightly rainfall for the above period are taken for the study. Data of many weeks specially at Pune are not available or have been rejected. As the beginning of cultivation entirely depends on monsoon rainfall the data are arranged from 23rd week to 22nd week of the next year.

3. Soils

Soils around Pune, called the black cotton types, are clayey in nature, of medium depth and of medium class porosity. Field capacity and permanent wilting point vary from 33 to 36 per cent and 15 to 18 per cent respectively on dry soil weight basis. The soil exhibits marked swelling and shrinking on wetting and drying.

Soils of Delhi area are the alluvial sandy loam type with uniform texture upto a depth of 100 cm and only minor pockets of clay and sand and of good permeability. Porosity in general is about 40 per cent. Field capacity and wilting point vary from 16 to 18 per cent and 7 to 9 per cent on dry weight basis respectively.

4. Discussions

For both Pune and Delhi, years in which rainfall amounts are in excess, normal and deficient have been taken and the weekly/fortnightly

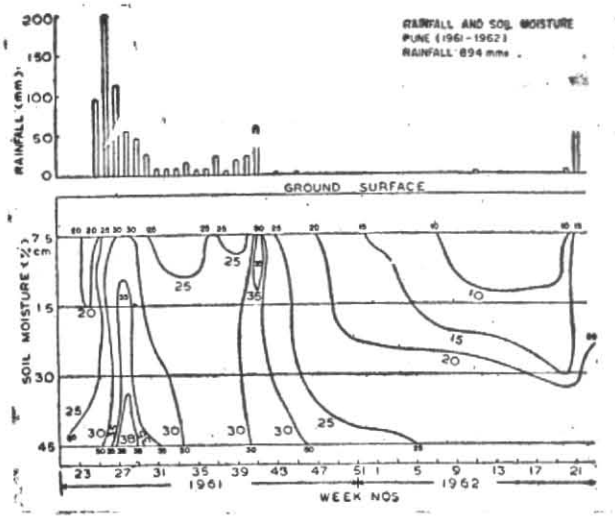

Fig. 1(a)

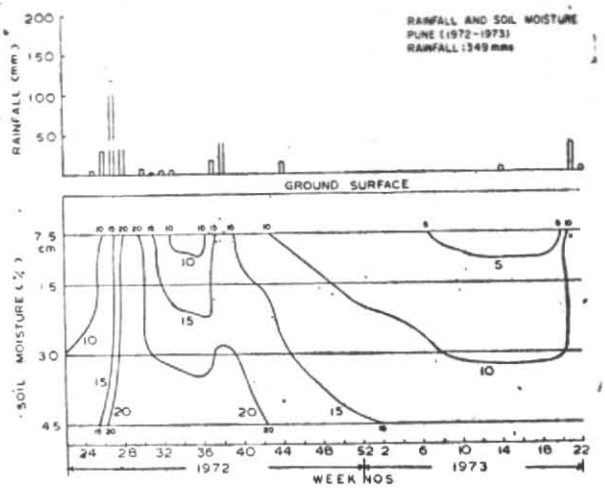

Fig. 1(c)

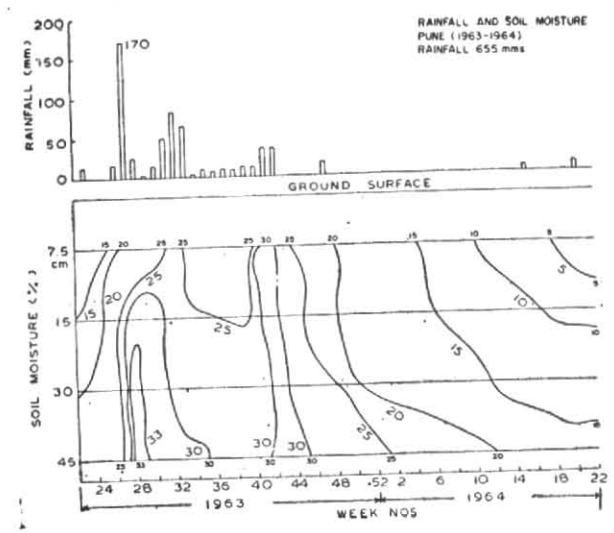

Fig. 1(b)

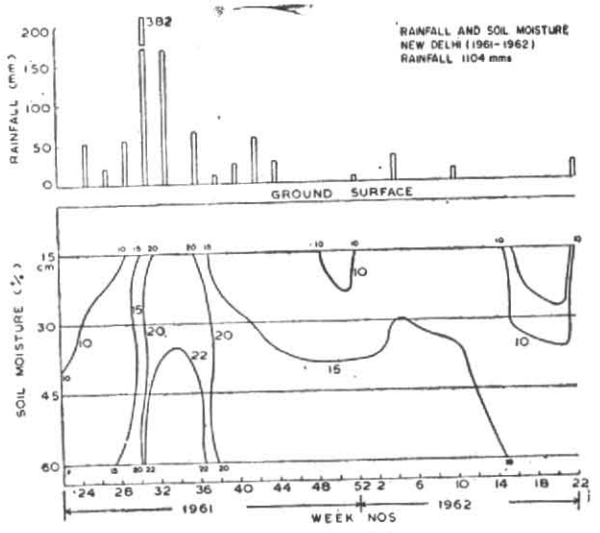

Fig. 2(a)

amount of rainfall and soil moisture percentage at different depths are plotted in Figs. 1 (a, b, c) & 2 (a, b, c). For Delhi, the moisture at depths 15, 30, 45 and 60 cm, have been considered, whereas at Pune, the depths chosen are 7·5, 15, 30 and 45 cm. The above difference is to take account of the greater penetration of evaporative depreciation and deeper concentration of absorbing roots in Delhi soil.

4.1. *Variation at Pune*

Fig. 1(a) gives the soil moisture of excess rainfall year 1961-62. In all the four layers, moisture varies from 23 per cent to 26 per cent in the 23rd week of 1961 due to good rainfall in the last week of May. Soil moisture entered into the field capacity range in two deeper layers in the 27th week and continued upto 30th week. It again exceeded 34 per cent at 7·5 and 15 cm depths in the 41st week and then a steady drop sets in at all the levels. Wilting range was reached at 7·5 and 15 cm depths in the 1st and 5th week respectively. Soil moisture was above wilting point at 30 and 45 cm layers throughout the year except the 20th week at 30 cm.

In the normal rainfall year 1963-64, Fig. 1(b), the soil moisture reached peak values in the 28th week at all the three deeper depths and at 7·5 cm in the 42nd week. Moisture was above field capacity at 30 and 45 cm for a brief period after 28th week.

There was a steep fall after 45th week, especially, in the first two depths. Soil moisture depleted below 15 per cent after 4th and 6th week

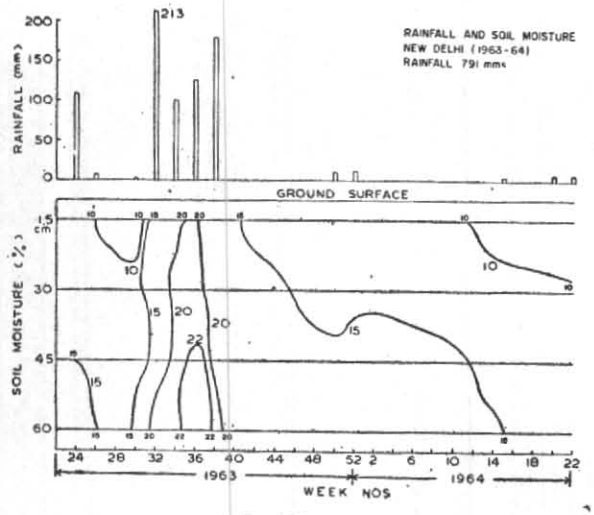

Fig. 2(b)

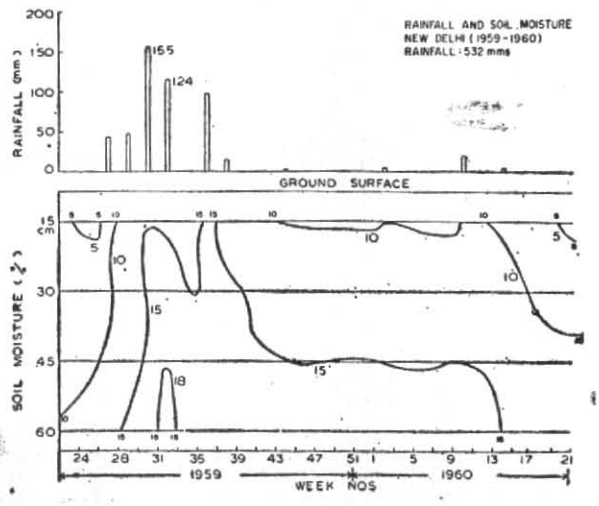

Fig. 2(c)

at 7·5 and 15 cm respectively and at 30 cm after 11th week.

During the period of study the lowest rainfall was recorded in 1972-73. Soil moisture was 6·3 per cent and 13·6 per cent at 7·5 and 45 cm depths respectively, at the beginning of the year as shown in Fig. 1(c). It attained the highest value of the year in the 28th week at all the levels which was of the order of 22-24 per cent. Moisture was depleted below wilting point in 32nd week at 7·5 and 15 cm depths. It entered into wilting range even at 45 cm later in the first week of January 1973. Moisture was again increased after 20th week due to 37 mm rainfall.

4.2. *Variation at Delhi*

Fig. 2(a) depicts the soil moisture of excess rainfall year 1961-62. Soil moisture recorded at 15 and 60 cm depths were 6·4 per cent and 13 per cent respectively in the 23rd week. In spite of 56 mm rainfall during 24th and 25th week, soil moisture was not increased much as rainfall was evenly distributed. Soil moisture was more than 22 per cent at the two deeper layers from 31st to 36th week on account of copious rainfall. It was above field capacity during the period 30th to 36th week in all the four depths and reduced to 14·6 per cent and 19·2 per cent at 15 and 60 cm depths respectively in the 37th week. There was a gradual fall till 3rd week of 1962 and it again increased in the 4th week due to 34 mm rainfall. Soil moisture was above wilting point throughout the year at all the three deeper layers.

Fig. 2(b) gives soil moisture of the year 1963-64. In the 24th week soil moistures were 13·7 per cent and 16·0 per cent at 15 and 60 cm depth respectively. A gradual depletion of moisture was noticed upto 30th week and then build up due to heavy rainfall and attained peak values at all the four depths in the 36th week. Soil moisture was above field capacity at 15 cm depth from 31st to 38th week and for longer period at deeper layers. After 38th week, there was hardly any rainfall upto 49th week. Soil moisture increased in 52nd week due to 18 mm rainfall. It then gradually decreased and entered into wilting range in 14th week at 15 cm depth only.

During the period of study, the year 1959-60, Fig. 2(c) recorded the lowest rainfall. Soil moisture reached a peak value in the 37th week at 15 and 30 cm depth and in the 32nd week at 45 and 60 cm depths. The moisture content remained almost steady from 45th to 50th week at 60 cm depth. However, depletions during the hot season took the moisture below wilting point at 15 and 30 cm depths.

5. Comparative agronomic implications

The quicker recharge of deeper depth moisture, rains at Pune may be facilitated by conductance through cracks and that in August atmosphere drought may reduce moisture content in root zone. In the post rainy season evaporation in vapour phase and development of crack will not allow any carry over of moisture to the next crop season even in excess rainfall years. This perhaps may confirm no benefit to the succeeding crop and sowing with good rains in 2nd and 3rd week of July and in any case in September is warranted at Pune.

At Delhi adequate infiltration rates in soil may be necessary to take advantage of July rains. Again evaporative depletion seems to

TABLE 1

Station — Pune

Soil depth (cm)	Meteorological week					
	3rd	8th	12th	16th	21st	25th
7·5	·60 / 31·4-6·2	·62 / 26·8-5·1	·69 / 30·8-5·1	·65 / 26·5-5·2	·58 / 31·3-6·5	·37 / 34·8-11·9
15	·51 / 30·0-8·9	·45 / 28·3-7·8	·55 / 31·7-6·4	·51 / 26·9-6·5	·61 / 34·0-7·7	·31 / 28·6-11·4
30	·29 / 26·1-11·2	·28 / 27·9-10·8	·24 / 26·8-13·9	·23 / 21·5-10·2	·47 / 29·3-9·3	·31 / 33·0-15·5
45	·32 / 28·3-13·9	·27 / 27·2-12·7	·26 / 30·3-11·3	·26 / 25·0-11·2	·35 / 28·6-11·5	·31 / 35·0-13·5

TABLE 1 *(contd)*

Soil depth (cm)	Meteorological week					
	29th	34th	38th	42nd	46th	50th
7·5	·26 / 34·7-16·0	·24 / 35·0-14·1	·24 / 33·7-16·1	·28 / 35·0-15·9	·45 / 33·0-8·4	·39 / 32·9-6·9
15	·23 / 35·0-16·8	·13 / 34·0-14·0	·17 / 33·9-15·5	·21 / 34·0-17·5	·39 / 35·0-8·2	·35 / 32·7-8·3
30	·24 / 34·6-17·6	·28 / 33·1-6·6	·18 / 32·4-16·3	·16 / 31·6-14·0	·29 / 31·4-12·8	·33 / 28·5-10·2
45	·26 / 36·0-15·1	·16 / 34·7-20·4	·16 / 33·3-22·0	·21 / 34·1-16·6	·27 / 34·5-13·2	·29 / 32·7-11·8

cease at the rooting depths when moisture content is high and is resumed only in summer. Thus, whatever moisture is conserved in the kharif season will be available almost entirely for the succeeding rabi crop and in a substantial quantity to the succeeding kharif crop following rabi fallow. Since the moisture content is above the wilting point except in deficit years, forced fallows will benefit the succeeding crop at Delhi.

6. Coefficient of variation

Tables 1 and 2 give the coefficient of variation (CV) values (numerator) and amplitude of soil moisture fluctuations in per cent (denominator) in Pune and Delhi. It is seen that maximum deviation of the moisture content from normal in the upper layers of soil both at Pune and Delhi are observed in summer. CV values are highest (0·58-0·69) at Pune and (·35–·51) at Delhi in the first layer when the moisture contents are relatively low. The CV values are somewhat lower in the monsoon season but the absolute values of the average moisture content over both the stations are rather high. The range of variation of moisture is also low at the monsoon season from July to October. These tables also show that the high variations in moisture content occur in the upper 30 cm layer of the soil. The coefficient of variation decreases sharply with increasing depth and equal to (0·16–·35) at Pune and

TABLE 2

Station — Delhi

Soil depth (cm)	Meteorological week					
	3rd	8th	12th	16th	21st	25th
15	·24 / 15·1-6·1	·23 / 12·9-6·7	·29 / 11·5-6·9	·35 / 11·9-4·7	·36 / 8·9-5·5	·51 / 11·1-2·3
30	·19 / 15·9-7·8	·26 / 15·1-9·3	·16 / 13·7-9·5	·17 / 13·5-8·6	·24 / 9·6-5·0	·34 / 12·5-4·5
45	·12 / 18·1-11·2	·16 / 18·4-11·7	·13 / 15·5-10·7	·18 / 14·5-9·5	·26 / 11·8-7·4	·29 / 14·4-7·0
60	·23 / 20·3-12·1	·11 / 20·3-15·4	·15 / 16·7-11·1	·16 / 15·3-9·7	·28 / 12·7-7·7	·25 / 16·9-7·4

TABLE 2 (*contd*)

Soil depth (cm)	Meteorological week					
	29th	34th	38th	42nd	46th	50th
15	·35 / 17·7-6·7	·29 / 18·5-6·7	·27 / 18·3-7·6	·26 / 16·6-9·2	·25 / 16·1-8·2	·26 / 16·7-7·9
30	·26 / 17·8-6·9	·23 / 19·7-10·6	·26 / 20·1-8·9	— / —	·20 / 16·3-8·9	·23 / 19·9-9·3
45	·28 / 21·7-10·0	·23 / 20·5-10·1	·28 / 22·8-12·9	·15 / 18·3-12·6	·18 / 18·9-13·3	·23 / 20.5-10.5
60	·17 / 21·9-10·1	·19 / 21·4-19·9	·18 / 25·1-13·9	·14 / 18·9-13·2	·16 / 19·5-14·9	·20 / 22·1-13·9

(·11–·28) at Delhi at 45 cm, 60 cm depths respectively. Thus, it can be assumed that the active layer where considerable moisture variations occur reaches a depth of 30 cm in the region of study.

7. Conclusions

(*i*) Active layer where considerable moisture variations occur reaches a depth of 30 cm in the region of study. The absolute moisture content in lower layer is generally higher than upper one.

(*ii*) Soil moisture at Pune geneally attains two peaks first in July and the other at the end of September and on a few occasions it exceeds field capacity during monsoon season. Moisture stress is normally felt during the month of August.

(*iii*) In most of the years, probably due to development of crack there may not be carry over of moisture for the next crop season at Pune.

(*iv*) Except one or two years soil moisture at 15 cm depth from July to February is below wilting point at Delhi. Soil moisture reaches field capacity almost every year in Delhi area specially in late monsoon.

(*v*) As the moisture at 30 cm depth is above wilting point in most of the years, forced fallow may benefit the succeeding crop in Delhi

area. Soil moisture in upper 30 cm depth may give good indication of different agricultural operations such as preparation of land and sowing.

Moisture status during the period 42nd to 45th week specially on Delhi area indicate possibility of sowing winter crops.

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